

Earliest Record of the Anomiid Bivalve *Pododesmus*: A New Species from the Lower Eocene of Western Washington

by

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Abstract. An anomiid bivalve, *Pododesmus (Pododesmus) dunhamorum* sp. nov., from lower Eocene shallow-marine strata in the upper part of the Crescent Formation on the west side of Dabob Bay, Jefferson County, eastern Olympic Peninsula, Washington, is the earliest known species of this genus and subgenus. The new species is one of two Eocene species of *Pododesmus* s.s. that inhabited hard substrate in nearshore waters along the Pacific coast of North America. The other species is *P. (P.) inornatus* (Gabb, 1864) from the middle Eocene of central California and southwestern Washington.

INTRODUCTION

Pododesmus sensu stricto (Bivalvia: Anomiidae) is known only from a few Tertiary fossil species in the Americas and New Zealand and two extant species in the Americas. The most widespread living species is *Pododesmus (P.) rudis* (Broderip, 1834), which is found byssally attached to rock, coral, shell, or other hard substrates in shallow waters along the coasts of South Carolina, Florida, Texas, Bermuda, West Indies, Brazil, and central Argentina (CARCELLES, 1941; ABBOTT, 1974; RIOS, 1975). According to ABBOTT (1974) and RIOS (1975), *Pododesmus leloiri* Carcelles, 1941, from the Golfo San Matias, Argentina, is probably a synonym of *P. (P.) rudis*. The only other undoubted living species of *Pododesmus* s.s. is *P. (P.) foliatus* (Broderip, 1834), which ranges from western Mexico to northern Peru (KEEN, 1971).

Described herein is a new species of *Pododesmus* s.s. from lower Eocene strata in the upper part of the Crescent Formation, western Washington (Figure 1). This is the earliest record of this genus and subgenus. Previously, the earliest record of *Pododesmus* s.s. was from middle Eocene strata in central California and western Washington (WEAVER, 1942 [1943]).

Abbreviations used for catalog and/or locality numbers are: CSUN, California State University, Northridge; LACM and LACMIP, Natural History Museum of Los Angeles County, Los Angeles, Malacology Section and Invertebrate Paleontology Section, respectively; UCMP, University of California Museum of Paleontology.

STRATIGRAPHIC DISTRIBUTION AND GEOLOGIC AGE

Pododesmus (P.) dunhamorum sp. nov. was found at three localities in the upper part of the Crescent Formation along the west side of Dabob Bay about 50 km west of Seattle, Jefferson County, Washington (Figure 1). Localities CSUN 1511 and 1512 are very near each other, and CSUN loc. 1502 is approximately 6 km farther north. Thirty-nine specimens were found, four at loc. 1502, 22 at loc. 1511, and 13 at loc. 1512. All are single valves; four left valves, 12 right valves, and 23 of which the valve type cannot be determined. Preservation ranges from poor to good, and at loc. 1511, 40% of the specimens are molds.

The lithologies at CSUN locs. 1511 and 1512 and their depositional environment and geologic age are discussed by SQUIRES *et al.* (1992). At both localities, there is fossiliferous pebble conglomerate interbedded with basalt units that were extruded into very shallow-marine waters. Erosion of the basalts by storm waves produced rubble that was transported offshore, where substrate-attaching species, like *Pododesmus (P.) dunhamorum*, were able to inhabit it. The upper Crescent Formation in this area is late early Eocene in age on the basis of its contained calcareous nannofossils, benthic foraminifera, and macrofossils. This age is equivalent to calcareous nannofossil Zones CP10-CP11, which straddle the boundary between the provincial molluscan "Capay Stage" and "Domengine Stage."

Fossils from CSUN loc. 1502 were collected from boul-

der-sized blocks of Crescent Formation that are within a modern landslide. The strata at this locality are lithologically, macrofaunally, and paleoenvironmentally similar to those at CSUN locs. 1511 and 1512. The rocks in the two areas are coeval (SQUIRES, 1992).

SYSTEMATIC PALEONTOLOGY

Family ANOMIIDAE Rafinesque, 1815

Genus *Pododesmus* Philippi, 1837

Type species: *Pododesmus decipiens* Philippi, 1837 [= *Placunanomia rudis* Broderip, 1834], by monotypy; Recent, South Carolina to Argentina.

Subgenus *Pododesmus* s.s.

Pododesmus (*Pododesmus*) *dunhamorum*
Squires, sp. nov.

(Figures 2–9)

Anomiid (*Pododesmus*-like, new genus?): SQUIRES *et al.*, 1992: 7, table 1, pl. 1, figs. 28–29.

Diagnosis: Medium-sized *Pododesmus*, ovate, sculpture of 15 to 17 radial ribs on both valves; byssal foramen small, closed by a calcareous plug immediately adjacent to moderately elevated crurum.

Description: Medium-sized *Pododesmus*, reaching 24 mm in height, ovate, slightly inequivalved with left (free) valve more inflated, slightly inequilateral, beaks central, shell thin. Left valve with approximately 15 to 17 low, somewhat irregular radial ribs; interior margin of valve flattened. Right valve with attachment scar covering anterior one-fourth of valve, remainder of valve with approximately 15 to 17 radial ribs, spinose near ventral margin of valve. Radial ribs smaller and more crowded anteriorly. Right valve with small byssal foramen, encircled by a low rim; lower half of byssal foramen plugged by a calcareous deposit. Foramen situated beneath and immediately adjacent to a moderately elevated crurum (= chondrophore). Crurum with a narrow slot for resilium. Interior of right-valve margin somewhat flattened.

Holotype: LACMIP 11515.

Type locality: CSUN loc. 1511, 47°44'45"N, 122°51'06"W.

Paratypes: LACMIP 12227–12229; all from CSUN loc. 1511.

Dimensions: Of holotype, height 20.9 mm, length 18.1 mm; paratype 12227, height 16 mm, length 14.5 mm; paratype 12228, height 24 mm, length 20 mm; paratype 12229, height 17 mm, length 16 mm.

Discussion: The new species is assigned to *Pododesmus* s.s. on the basis of the combination of the following features: radial sculpture on both valves, small plugged byssal foramen, and the unnotched dorsal margin of the relatively

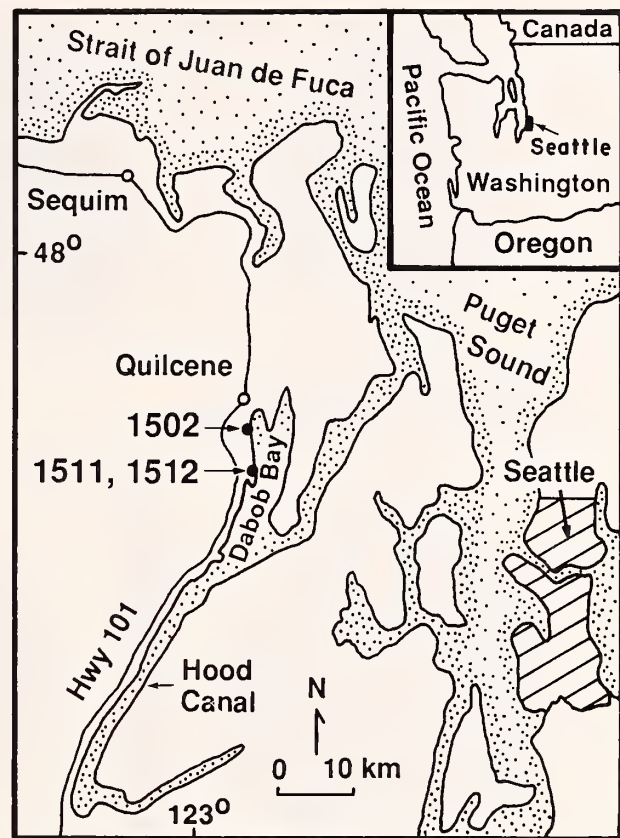


Figure 1

Location map for localities of *Pododesmus* (*Pododesmus*) *dunhamorum* Squires, sp. nov.

thick right valve. The new species is remarkably similar to *Pododesmus* (*P.*) *decipiens*, the type species of *Pododesmus* s.s., and especially to specimens (LACM 78-95, LACM 78-96) of the type species from Golfo San Jose, Chubut Province, Argentina. OLSSON & PETIT (1964:529–530, pl. 77, fig. 1) gave a detailed description of *Pododesmus* (*P.*) *rudis* (Broderip, 1834), the junior subjective synonym of *P.* (*P.*) *decipiens*, and figured the interior of the right valve. CARCELLES (1941:pl. 1, figs. 1, 2) and KEEN (1969:fig. C103 12a, b) also provided illustrations of *P.* (*P.*) *rudis*.

The shell of *Pododesmus* is morphologically similar to that of *Anomia* Linné, 1758, the main distinction being that *Pododesmus* has two muscle scars in the central “white area” on the interior of the left valve rather than three, as in *Anomia* (BEU, 1967; KEEN, 1969). Also, in *Pododesmus* both valves are radially sculptured, opaque, and fairly thick, whereas in *Anomia* the right valve lacks radial sculpture and both valves are translucent and usually thin (BEU, 1967). *Pododesmus* is further distinguished by a byssal foramen that may be partially or entirely closed and which does not open as a slit at the dorsal margin, and a byssal plug that may be retained within the foramen (BEU, 1967; KEEN, 1969). Although the muscle scars on the left valve are not preserved in the new species, the overall mor-



Explanation of Figures 2 to 9

Figures 2-9. *Pododesmus (Pododesmus) dunhamorum* Squires, sp. nov., CSUN loc. 1511. Figures 2-3: paratype, LACMIP 12227, left valve, $\times 2.6$; Figure 2, exterior; Figure 3, interior. Figures 4-7: holotype, LACMIP 11515, right valve, $\times 2.5$; Figure 4, exterior; Figure 5, interior; Figure 6, dorsal view of hinge line; Figure 7, anterior view. Figure 8: paratype, LACMIP 12228, right-valve interior, $\times 2.2$. Figure 9: paratype, LACMIP 12229, right-valve interior, $\times 2.4$.

phology of both valves is in keeping with features of *Pododesmus* rather than of *Anomia*.

Pododesmus is anatomically the most primitive living anomiid (YONGE, 1977, 1980), and it probably evolved into *Anomia* (YONGE, 1977). Using shell microstructure of primarily the right valve, CARTER (1990) subdivided the anomiiids into three groups. The only species of *Pododesmus* that he studied was the living *Pododesmus (Monia) macrochisma* (Deshayes, 1839), and he included it among the "*Anomia simplex* group" that is characterized by a right valve with an outer layer of calcitic simple prisms and inner layers of aragonite and a left valve that always has a prominent layer of foliated structure. This group represents a primitive microstructure grade that is compatible with the primitive soft anatomy of *P. (M.) macrochisma* (CARTER, 1990).

KEEN (1969) recognized four subgenera in *Pododesmus*: *Pododesmus* s.s., *Monia* Gray, 1850, *Heteranomia* Winck-

worth, 1922, and *Tedinia* Gray, 1853. The only two subgenera with a known fossil record are *Pododesmus* s.s. and *Monia*. KEEN (1969) distinguished these two genera on the basis of the size of the byssal foramen, with *Pododesmus* having a much smaller one. HERTLEIN & GRANT (1972) reported *Pododesmus* as having thicker valves and a smaller foramen than *Monia*, and that the foramen is always plugged in *Pododesmus* but is usually open in *Monia*. BEU (1967) considered *Monia* to be a distinct genus and not a subgenus of *Pododesmus*. He noted that the right valve of *Pododesmus* is considerably thicker than the very thin right valve of *Monia* and that the byssal plug is small and permanently fused into the shell in *Pododesmus*, whereas in *Monia* the byssal plug is large, thin, and completely free. Further, in *Pododesmus* the crurum is approximately triangular, with anterior and posterior dorsal resilial surfaces, whereas in *Monia* the crurum has only a single dorsal resilial surface. Although the crurum of the new species is not well pre-

served and is incomplete even on the holotype, the other morphologic features indicate placement in *Pododesmus* s.s. rather than in *Monia*.

The new species is similar to *Pododesmus paucicostatus* BEU (1967:240, pl. 1, fig. 3; pl. 2, figs. 6, 9, 10; text-figs. 2a, d) from the middle Miocene of New Zealand (BEU & MAXWELL, 1990). Beu's species has all the diagnostic features of *Pododesmus* s.s. and is judged herein to be assignable to *Pododesmus* s.s. The new species differs from Beu's species in the following features: smaller valve size, thinner valves, and smaller byssal foramen.

The new species is also similar to *Paranomina scabra* (MORTON, 1834; WADE, 1926:67–68, pl. 22, figs. 3–9) from Upper Cretaceous strata in the southeastern part of the United States. The new species, however, is smaller, it has coarser and more closely spaced radial ribs, and a byssal foramen is located much closer to the crurum and lacks the long linear scar between the foramen and the crurum.

Only two other Eocene anomiiids are known from the Pacific coast of North America. One is *Pododesmus inornatus* (GABB, 1864:217, pl. 32, figs. 288, 288a) from the middle Eocene in central California and southwestern Washington (STEWART, 1930; VOKES, 1939; WEAVER, 1942 [1943]; KEEN & BENTSON, 1944; MOORE, 1987). VOKES (1939:57–58, pl. 3, figs. 6, 7, 9, 11) assigned *P. inornatus* to *Pododesmus* (*Monia*). Only one of the figured specimens (UCMP hypotype 15587, see VOKES, 1939:pl. 3, fig. 6) shows the interior of the right valve of *P. inornatus*. The byssal foramen and crural area are very similar to that of the new species, and I believe that *P. inornatus* should be placed in *Pododesmus* s.s. and not in *Monia*. The only other figured specimen of *P. inornatus* that shows the byssal foramen area is UCMP hypotype 15589 (see VOKES, 1939:pl. 3, fig. 11), but only the exterior of the right valve is free of matrix. Vokes' illustration is misleading because it gives the impression that the foramen is free of matrix. The area around the foramen has been excavated, and the border of the foramen is no longer present. It is impossible to tell what the exact diameter of the foramen was, and the larger diameter may be an artifact. Nevertheless, the foramen is smaller than that normally present on specimens of *Monia*. *Pododesmus* (*P.*) *dunhamorum* differs from *Pododesmus* (*P.*) *inornatus* (Gabb, 1864) in having a less-inflated left valve, fewer but much stronger radial ribs on the left valve, an ornamented right valve, and in lacking commarginal riblets or lamellae on the left valve.

The other reported Eocene anomiid from the Pacific coast of North America is *Anomia mcgoniglenensis* HANNA (1927:278, pl. 31, figs. 1, 2, 5, 7), from middle Eocene ("Domengine Stage") strata of the San Diego area, southern California, to southwestern Oregon (KEEN & BENTSON, 1944; TURNER, 1938; WEAVER, 1942 [1943]; GIVENS & KENNEDY, 1976; SQUIRES, 1984, 1989; MOORE, 1987). VOKES (1939) questionably put *A. mcgoniglenensis* into synonymy with *Pododesmus* (*Monia*) *inornatus* because the range in coarseness of sculpturing in *A. mcgoniglenensis* over-

laps with that observed in *P. (M.) inornatus*. GIVENS & KENNEDY (1976), however, established *A. mcgoniglenensis* as a species of *Anomia*, on the basis of well-preserved left valves that show three, rather than two, muscle scars.

The only other Pacific coast of North America Paleogene anomiid species that has been assigned to *Pododesmus sensu lato* is *P. newcombei* CLARK & ARNOLD (1923:141, pl. 21, figs. 3–6; WEAVER, 1942 [1943]: 100–101, pl. 23, figs. 2, 3, 5) from the upper Oligocene Sooke Formation, on southern Vancouver Island, British Columbia. The interior of this species is unknown, but *P. (P.) dunhamorum* differs from it by having a much flatter right valve, coarser radial ribs, and fewer and more widely spaced radial ribs. CLARK & ARNOLD (1923) noted that *P. newcombei* is similar to *P. macrochisma* (Deshayes, 1839) [= *P. cepio* (Gray, 1850)]. Modern workers assign Deshayes' species to the subgenus *Monia*. *Pododesmus* (*Monia*) *macrochisma* ranges today along the Pacific coast of North America and in Japan, and is known as a fossil from rocks as old as late Miocene (MOORE, 1987).

By late Eocene, *Pododesmus* s.l. was present in New Zealand, and *Pododesmus* s.s. lived there from Oligocene through middle Miocene (BEU, 1967; BEU & MAXWELL, 1990). IHERING (1907) reported four species of *Pododesmus* from the Patagonian Formation in Patagonia, southern Argentina, and DAVIES (1975) considered this formation to be early Miocene in age. HERTLEIN & GRANT (1972), however, concluded that Ihering's generic assignment of his four species is tenuous because of their poor preservation. *Pododesmus* (*P.*) *rudis* has been reported from Pliocene rocks in Venezuela (WEISBORD, 1964). *Pododesmus* s.l. was present along the Gulf Coast of North America by the early Pleistocene (OLSSON & PETIT, 1964; WARD & BLACKWELDER, 1987) and today persists there as *P. (P.) rudis*, which also lives in the West Indies and along much of the western Atlantic coast of South America. GARDNER'S (1926) report of *P. (P.) rudis* from the upper lower Miocene Chipola Formation in Florida and a report of this species from the lower Pleistocene Waccamaw Formation in North Carolina could not be substantiated by WEISBORD (1964) and WARD & BLACKWELDER (1987), respectively.

The geologic range of *Pododesmus* s.s., previously reported as Miocene to Recent (KEEN, 1969; DAVIES, 1971), is emended herein as late early Eocene to Recent.

Etymology: The species is named for George and Cressie Dunham, whose cooperation made the discovery of this new species possible.

Distribution: Upper lower Eocene (near boundary between "Capay Stage" and "Domengine Stage"), upper Crescent Formation, west side of Dabob Bay, eastern Olympic Peninsula, Jefferson County, western Washington (CSUN locs. 1502, 1511, and 1512).

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- CSUN loc. 1511. Pebble conglomerate, 63 m above base of stratigraphically lowermost sedimentary interbed found along seacliff on west side of Dabob Bay at Pulali Point, latitude 47°44'45"N, longitude 122°51'06"W, central part of section 18, T26N, R1W, U.S. Geological Survey, 7.5-minute, Seabeck, Washington quadrangle, 1953 (photorevised 1968), eastern Olympic Peninsula, Jefferson County, western Washington. Upper Crescent Formation. Age: Late early Eocene (near boundary between "Capay Stage" and "Domengine Stage"). Collectors: J. L. and G. H. Goedert and K. Kaler, 1989–1991. (See SQUIRES *et al.*, 1992:figs. 2, 3).
- CSUN loc. 1512. Same as the CSUN loc. 1511, except 106 m stratigraphically higher in section.

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